

STATE OF ALASKA

Jay S. Hammond, Governor

Annual Performance Report for

COHO SALMON STUDIES IN THE RESURRECTION BAY AREA

by

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RESEARCH PROJECT SEGMENT

State: ALASKA

Name: Sport Fish
Investigations

Project No.: F-9-14

Study No.: G-II

Study Title: SPORT FISH STUDIES

Job No.: G-II-A

Job Title: Coho Salmon Studies
in the Resurrection
Bay Area

Cooperator: Edward T. McHenry

Period Covered: July 1, 1981 to June 30, 1982

ABSTRACT

Bear Lake was restocked with 247,845 Age 0.0 coho salmon, Oncorhynchus kisutch (Walbaum), fingerlings on June 2, 1981 to maintain smolt production.

The Bear Creek weir downstream migrant trap was operated continuously from May 13 through September 30. A total of 72,888 Age 1.0, 2.0 and 3.0 smolts were enumerated. Yearling (Age 1.0) smolt survival from the 1980 Bear Lake fingerling plant was 7.3 percent, with a ratio of 0.7:1.0 smolt-to-fingerling biomass (kilogram) yield. Age 2.0 smolt survival from the 1979 fingerling release was 27.4 percent, with an 8.7:1.0 smolt-to-fingerling biomass ratio.

Bear Lake's smolt out-migration timing and abundance, age and size composition and condition factors are presented. Bear Creek water temperatures and stream flows corresponding to migration peaks and durations are also given. The abrupt decline in 1980 and 1981 yearling smolt production from the 1979 and 1980 fingerling releases and the possibility of improving Bear Lake's carrying capacity via artificial fertilization are discussed.

The Resurrection Bay salmon creel census (July 8-September 8) indicated an estimated 15,743 coho salmon were harvested by 22,937 man-days of effort. The mean seasonal catch per angler hour was 0.122. Enhanced coho salmon production contributed an estimated 11.3 percent to the sport harvest. Most (93 percent) survived from 18,377 marked and 56,545 unmarked Bear Lake smolts that emigrated in 1980. The remaining 7 percent returned from 42,440 Ad-CWT marked and 124,230 unmarked Age 0.0 (1979 brood, Bear Lake origin) hatchery smolts released in Seward Lagoon and Grouse Lake in late June 1980. Negligible adult survivals of the latter are reviewed.

The Bear Creek weir upstream migrant trap was operated continuously from May 16 through November 13. The coho salmon upstream migration to the trap extended from August 11 to November 11 and consisted of 3,924 adults and 16

jacks. Adults were comprised of: 1 adipose-clipped coded wire tag (Ad-CWT), 184 right ventral, 6 ventral and 3,733 unmarked coho salmon. The 16 jacks (salmon) resulted from 54,646 Bear Lake smolts released unmarked past Bear Creek weir in 1981.

Total smolt-to-adult survival per release lot was 7.95 percent (Bear Lake), 0.37 percent (Grouse Lake) and 0.25 percent (Seward Lagoon). Total survival of Bear Lake smolt out-migrations (1973-1980), Bear Creek (1969-1979), Seward Lagoon (1968-1980) and Grouse Lake (1976-1980) hatchery smolt releases are summarized.

The catch-to-escapement ratio of marked Bear Lake coho salmon was 0.36:1.0. The adult male-to-female sex ratio was 1.7:1.0 in the Bear Creek escapement. An estimated 2,003,800 fertilized eggs were artificially spawned from 472 females and 135 males from the Bear Lake return.

Data on the timing and abundance of other fish species ascending and descending Bear Creek to the weir are presented.

KEY WORDS

Bear Lake, Kenai Peninsula, coho salmon, stocking density, biomass production, lake fertilization, population abundance, age composition.

BACKGROUND

Wild coho salmon production in Resurrection Bay is believed to be directly affected by the extreme fluctuations in stream flows and water temperatures characteristic of its drainage streams. Since 1961, the Resurrection Bay coho salmon recreational fishery has become the largest marine sport fishery for this species in Alaska. Therefore, it became imperative to stabilize or improve Resurrection Bay coho salmon production to satisfy growing angler demand in the fishery. Figure 1 shows the Resurrection Bay drainage and Table 1 lists the anadromous fish species indigenous to its tributaries.

Bear Lake, located 7 miles north of Seward, was chosen for coho salmon rearing because it is the largest (180 hectares or 445 acres) stable body of clear freshwater in the Resurrection River drainage and is accessible by road. It was determined, after a survey in 1962, that Bear Lake should be rehabilitated with rotenone to eradicate all predator and competitor fish species inhabiting the lake. Without predation and interspecific competition, it was believed Bear Lake could then produce a high sustained smolt yield from annual coho salmon fingerling plants.

Pre-rehabilitation species abundances were measured by a temporary weir situated at the Bear Creek/Salmon Creek confluence from 1961 to 1964. Upstream migrations averaged 921 adult coho salmon (1961-1964); 4,801 adult sockeye salmon (1961-1965); and 10,543 Dolly Varden (1961-1962). Downstream migrations in 1962-1963 averaged 7,933 coho salmon smolts, 51,232 sockeye salmon smolts and 17,838 Dolly Varden. Though threespine stickleback downstream migrations were not estimated at the weir, beach seine sampling indicated this species was abundant in Bear Lake.

FIGURE 1.

RESURRECTION BAY WATERSHED

- | | |
|------------------------|--------------------|
| 1. Salmon Creek | 2. Bear Creek |
| 3. Grouse Creek | 4. Bear Creek Weir |
| 5. Airport Creek | 6. Jap Creek |
| 7. Dairy Creek | 8. Seward Highway |
| 9. Grouse Lake | 10. Seward |
| 11. Resurrection River | |
| 12. Mayor Creek | |
| 13. Small Boat Harbor | |
| 14. Seward Lagoon | |
| 15. Clear Creek | |
| 16. Box Canyon Creek | |

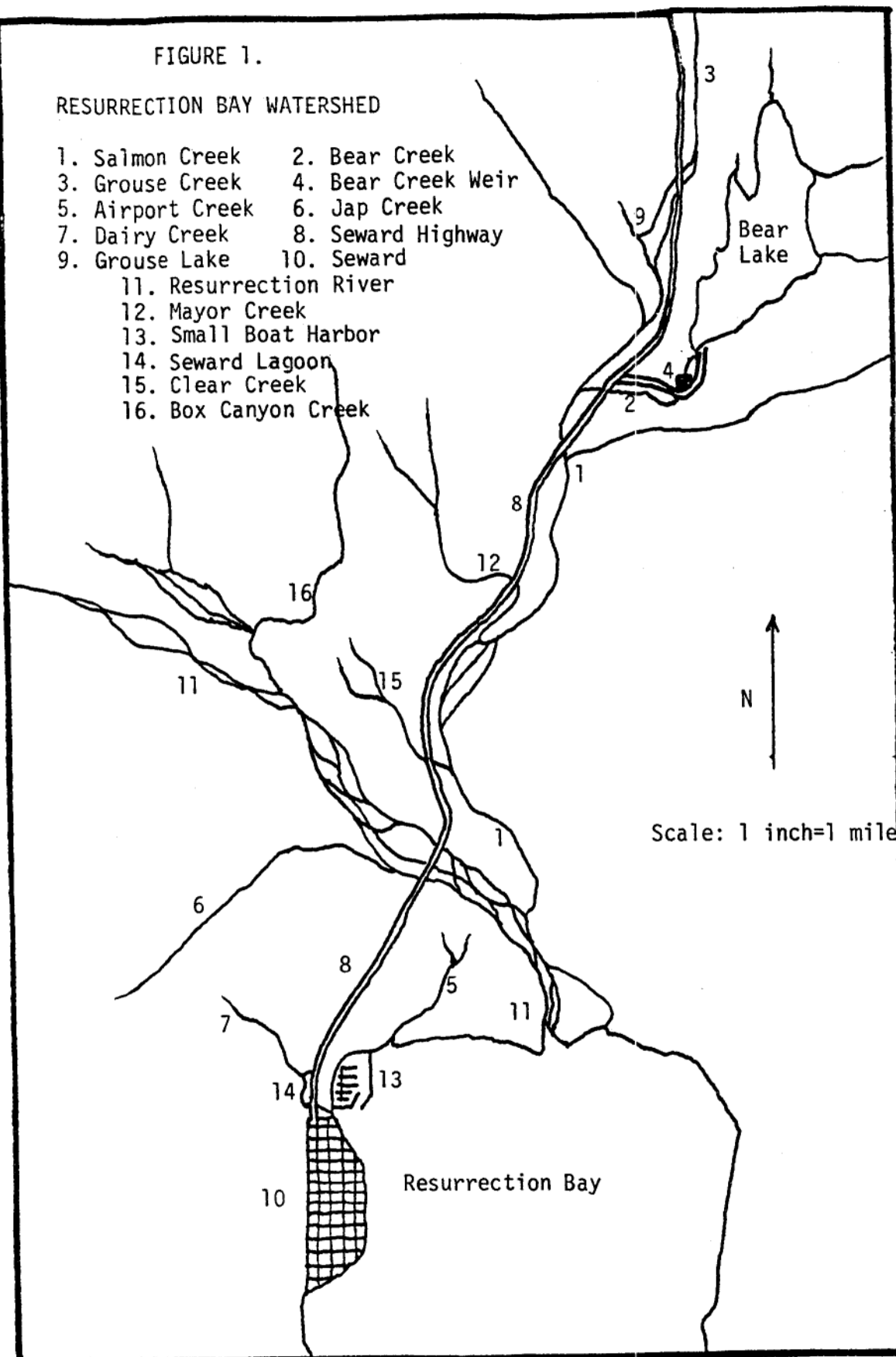


Table 1. Checklist of Fish Species Present in the Resurrection Bay
Drainage Tributaries.

Common Name	Scientific Name and Author
Dolly Varden	<u>Salvelinus malma</u> (Walbaum)
Rainbow-steelhead trout	<u>Salmo gairdneri</u> Richardson
Sockeye salmon	<u>Oncorhynchus nerka</u> (Walbaum)
Coho salmon	<u>Oncorhynchus kisutch</u> (Walbaum)
Chum salmon	<u>Oncorhynchus keta</u> (Walbaum)
Chinook salmon	<u>Oncorhynchus tshawytscha</u> (Walbaum)
Pink salmon	<u>Oncorhynchus gorbuscha</u> (Walbaum)
Threespine stickleback	<u>Gasterosteus aculeatus</u> Linnaeus

Bear Lake was rehabilitated with powdered rotenone at 1.0 mg/l (5% level) on August 26, 1963. A 1.5m (5-ft) high dam was erected at the outlet to contain the treated water until detoxification and to prevent subsequent immigration of undesirable species. Bear Lake detoxified by October 17, 52 days after the water was treated, and received its first annual fingerling plant that winter through the ice. All fingerling plants except the 1966 release were fin-marked at Fire Lake Hatchery to facilitate smolt survival evaluation.

The Good Friday earthquake on March 27, 1964 destroyed the outlet dam, which washed out completely on May 25. This allowed unobstructed entry of all fish ascending Bear Creek into Bear Lake until June 15 when the barrier was repaired. A permanent weir was constructed 533.4 m (1,750 ft) downstream from the outlet to assess Bear Lake's coho production and returning adult migrations.

Bear Lake became reinfested with threespine stickleback. It is not known whether this was due to insufficient rotenone treatment or the destruction of the outlet barrier. Also, Dolly Varden were able to negotiate the weir during fall flood levels and immigrate into the lake on most years.

Before rapid expansion of the stickleback population occurred, Bear Lake's coho and sockeye salmon smolt production increased several fold as a result of favorable rearing conditions from 1964 to 1966. Coho salmon smolt biomass (weight) production attained 4.2 kg for each kg of fingerlings planted in 1964. Smolt age structures changed from predominantly Age 2.0 to Age 1.0 with growth exceeding that of former Age 2.0 smolts. Smolt survival from stocked coho salmon fingerlings reached 43.5% of the 1964 and 48.1% of the 1965 plants.

Had sufficient coho salmon fingerlings been available for stocking Bear Lake at desired densities in 1963-1965, coho salmon smolt production would have been considerably higher. Bear Lake's enhanced smolt production increased pre-rehabilitation abundances of adult sockeye and coho salmon by 11 and 3.5 times, respectively.

Bear Lake's high smolt production was short lived, however, due to the stickleback's rapid takeover of the rearing environment, beginning in 1967. Smolt age structures reverted to Age 2.0 dominance, growth rates declined, and fingerling-to-smolt survivals decreased. Coho salmon fingerling plants were terminated after 1967 because smolt production was obviously dropping below pre-rehabilitation levels. By 1968, threespine stickleback had already reached pre-rehabilitation abundance in the lake.

In 1969, it was decided to rehabilitate Bear Lake again. Stickleback population sampling in 1970 showed that this species inhabited all areas and depths in Bear Lake. Bear Creek weir was reconstructed in 1969 and made entirely fishtight by removing the sloping upstream fence and adding three permanent, perforated plate screens above the upstream migrant trap.

Bear Lake was rehabilitated again in 1971, and lake treatment was conducted essentially the same as in 1963 except that 100% emulsified instead of powdered rotenone was used. Overall treatment level was 1.6 mg/l rotenone at 5% concentration. Caged live fish suspended from surface to bottom, 12 to 18 m (40 to 60 f), were all dead within 1 week. Population sampling 2

days following rehabilitation showed that the threespine stickleback comprised 98.8% of the total fish sample (n=9,065) collected randomly on and around Bear Lake. From this it was concluded that obtaining less than total lake rehabilitation in 1963 ultimately resulted in lower-than-normal salmon production in Bear Lake over the long term.

Bear Lake remained toxic through the winter of 1971-1972, and finally detoxified shortly after spring overturn. Annual coho salmon fingerling plants in Bear Lake resumed in June 1972 at desired stocking densities. Resultant smolts were enumerated, sampled weekly for age and size composition as well as condition factor, and fin-marked for recognition in the fishery before being released at Bear Creek weir. No threespine stickleback have been detected in Bear Lake during fall population sampling of juvenile coho salmon by electrofishing or at Bear Creek weir since the 1971 rehabilitation.

Bear Lake was stocked from 1972-1975 at densities ranging from 2,461 to 2,503 fingerlings per surface hectare. The cumulative effect in just 3 years resulted in critically overstocking Bear Lake's coho salmon rearing habitat.

Intense intraspecific competition among fingerlings evidently depressed growth rates, lowered survival and extended rearing duration to smoltification. Mean seasonal condition factors of all smolts sampled each year were observed to drop from 0.98 (1973) to 0.90 (1974) and 0.89 (1975). The percentage of fingerling plants resulting in Age 1.0 smolts also decreased from 17.2% (1973) to 14.5% (1974) and 3.0% (1975). Similarly, biomass ratios of Age 1.0 smolts produced per fingerling release declined abruptly from 8.9:1 (1973) to 4.9:1 (1974) and 0.4:1 (1975).

Increased stress from overcrowding apparently led to greater susceptibility (lowered resistance) of rearing fingerlings to natural diseases in Bear Lake. Though the 1975 smolt out-migration (168,036 smolts) was the largest ever recorded for Bear Lake, over 91% were Age 2.0 smolts in relatively poor condition. Nearly 13% of the smolt run died from "eye fluke", Diplostomulum spathaceum, and fungus, Saprolegnia sp., diseases at the weir. Only 1.1% of the 143,589 smolts released in 1975 survived to return as adults in 1976. A downward adjustment in Bear Lake's fingerling stocking density was, therefore, clearly indicated from these findings. Bear Lake has been stocked since 1976 at only 832 to 1,265 per hectare or approximately one-half previous levels, to enhance fingerling growth and survival to smolts. The following report presents the findings and discusses the results of this reduced fingerling stocking density on Bear Lake's coho salmon production.

RECOMMENDATIONS

1. The present objectives of the study should be retained.
2. The 1983 stocking density of coho salmon fingerlings in Bear Lake should be adjusted according to emigrating smolt abundance, age composition and condition factor in 1982.

3. Size of fingerlings stocked annually in Bear Lake should not average less than 772/kg (350/lb) to preclude residualism beyond Age 1.0 smolts.
4. The Bear Lake fertilization experiment should be continued if smolt biomass production increases significantly.

OBJECTIVES

1. To determine the distribution, abundance and timing of out-migrant and adult coho salmon in the Resurrection Bay area.
2. To determine the age and size composition of out-migrant and adult coho salmon populations in selected tributaries.
3. To determine the sport harvest and relative survival of wild and enhanced coho salmon stocks in Resurrection Bay.
4. To determine the methods and means of increasing or extending the freshwater spawning and rearing areas of the watershed and mitigating freshwater mortality.
5. To provide recommendations for the management of coho salmon in these waters and direct the course of future studies.

TECHNIQUES USED

The timing and abundance of sockeye and coho salmon smolts emigrating from Bear Lake downstream to Bear Creek weir were determined by enumerating these fish at the downstream migrant trap. Weir location and description of the downstream trapping facilities were presented by Logan (1969). The timing and abundance of adult sockeye and coho salmon were measured by enumerating these fish at the weir's upstream migrant trap. Adult trapping facilities, rebuilt in 1969 and modified in 1970, were described by McHenry (1971).

Bear Creek water temperatures and stream flows were recorded daily at the weir to subsequently correlate these physical parameters with the onset, peak and termination of migrations.

Age and size composition of Bear Lake sockeye and coho salmon smolt populations were determined by weekly sampling at the weir. Age compositions of Bear Lake sockeye and coho salmon smolt populations were determined by examining representative scale impressions on 0.5 mm cellulose acetate with a Bruning model 200 microfiche reader. Smolt abundance per age group was calculated by extrapolating the age composition, as determined in weekly scale sample analysis, to the total number of smolts emigrating during those weekly periods. Smolt size compositions were estimated by randomly measuring fork length in millimeters and recording weight in grams with an Ohaus triple beam balance from weekly samples throughout emigration. Age

and size composition of the Resurrection Bay wild coho salmon return was not sampled because these fish could not be differentiated from adults surviving from the unmarked components of hatchery smolt releases in 1980. Age and size composition of the Bear Lake adult coho and sockeye salmon returns was determined by randomly sampling 20% of their escapements for representative scale impressions, fork length (mm), weight (kg) and sex. All fish sampled were anesthetized in a 50 mg/l solution of MS-222 (Tricaine methanesulfonate) to facilitate handling and minimize mortality.

Extending the Resurrection Bay watershed's freshwater spawning and rearing areas was accomplished by timely removal of beaver dams during juvenile and adult coho migration periods in Airport rearing pond outlet and Jap Creek. Mitigating freshwater mortality is being attempted in Bear Lake via the recently initiated fertilization project.

Resurrection Bay coho salmon sport harvest and angler effort (man-days) were measured by a stratified, random creel census conducted at the Seward small boat harbor. Sampling design and interview method were nearly identical to that described by Logan (1966). The average number and percentage of sport fishing boats returning to the Seward small boat harbor were determined for each of three 3.5-hour sampling periods extending from 11:30 a.m. to 10:00 p.m. Returning boats were not sampled from 8:00 a.m. to 11:30 a.m. because only 11.6% of the weekend and 14.3% of the weekday sport craft returned during this period in the 3 years sampled (1964-1966). The mean number of boats returning during this morning period was extrapolated using the above percentages. These estimates were then added to those determined for the three periods sampled to estimate total daily boats.

Total sport fishing effort and harvest were estimated for the season by multiplying weekly means (anglers/boat and salmon/boat) times total returning boats for all weekends and weekdays included in the creel census period. Fishing mortality and catch-to-escapement ratio of unmarked and marked (fin-clipped) adult coho salmon were determined by extrapolating the marked coho salmon catch observed during creel census and by recording marked versus unmarked coho salmon in the Bear Lake, Grouse Creek and Seward Lagoon spawning escapements. Coho salmon taken in the shore fishery after the boat creel census terminated were considered "escapement" for the Resurrection Bay catch-to-escapement ratio determination.

Evaluation of Bear Lake's rehabilitated rearing environment was continued by measuring the abundance, growth and condition of smolt surviving from the 1978, 1979 and 1980 coho salmon fingerling plants. Smolt biomass (kilograms) production was calculated by multiplying the seasonal mean smolt weight (grams) per age group by the total number of smolts emigrating in each age group in 1981.

FINDINGS

Results

The findings presented are the result of the 1981-82 research segment of the project. For a description of the Resurrection Bay drainage and past information collected on the project, see Logan (1962-1969) and McHenry (1970-1981).

Bear Lake Coho Smolt Migration

The Bear Creek weir downstream migrant trap was operated continuously from May 13 through September 30, when the trap was removed due to cessation of the Bear Lake smolt emigration in late September. Abundance and timing of the coho salmon smolt out-migration are shown in Table 2. Stocked fingerlings emigrating Bear Lake were retained above the weir.

The out-migration to the downstream trap totaled 72,888 smolts. Trap mortality claimed only 265 smolts (0.14% of the run) due to careful manipulation of the fish pass elevation during fluctuating weir pool levels at migration peak. A total of 72,623 live smolts were released downstream. A predetermined 24.8% of the out-migration received a left ventral (LV) fin-clip for recognition in the 1982 Resurrection Bay sport fishery and Bear Lake spawning escapement. Table 3 shows the number and percentage of smolts marked and sampled in each weekly period.

Smolt emigration began on May 13, peaked (50% of out-migration) by June 16 and terminated September 27. The highest daily count occurred on June 15 when 5,448 (7.5% of the total run) were enumerated from the trap. Mean stream temperatures when smolt emigration began, peaked and terminated were 4.7°C (40.5°F), 13.3°C (56.0°F) and 8.1°C (46.5°F), respectively. Bear Creek stream flows ranged from 17 to 106 cfs during this period.

The smolt out-migration was comprised of 15.0% (10,899) Age 1.0, 84.7% (61,750) Age 2.0 and 0.3% (239) Age 3.0 smolts. Tables 4 and 5 present the mean fork length, weight, condition factor and relative percentage of Age 1.0 and 2.0 smolts in the weekly samples. Too few Age 3.0 smolts were observed for tabulation. Table 6 shows the weekly and seasonal smolt abundance per age group. An overall 0.9% (683 smolts) was representatively sampled during emigration (Table 3). An estimated 10,859 Age 1.0, 61,526 Age 2.0 and 238 Age 3.0 live smolts were released downstream.

Nearly half (45%) of the Age 3.0 smolts emigrated on June 3-9 when Bear Creek water temperatures averaged 9.5°C (49.1°F), while the Age 2.0 and Age 1.0 smolt migrations peaked during June 10-16 and June 17-23, respectively, at mean stream temperatures of 11.6°C (52.8°F) and 13.9°C (57.1°F) in those weekly periods.

Bear Creek weekly stream temperatures averaged about 3.9°C (7.0°F) warmer than those measured during the same migration peak period in 1980, evidently resulting in a more normal smolt emigration timing. Only 40% of the 1980 smolt out-migration was processed through the downstream trap by mid-June when stream temperatures averaged 6.3°C (43.4°F), whereas 55% of the 1981 Bear Lake smolt migration had descended to the weir by June 16. In previous years (1974-1979), about 65% of Bear Lake smolt out-migrations had reached the weir by the end of the first week that Bear Creek mean water temperature exceeded 10°C (50°F).

The 239 Age 3.0 smolts resulted from the seventh fingerling plant (225,800 Age 0.0 fingerlings in 1978) in Bear Lake following the 1971 lake rehabilitation project. Total fingerling-to-smolt survival from the 1978 plant was 52.1%. Age composition of this smolt production cycle was 82.6%

Table 2. Bear Lake Coho Salmon Smolts Enumerated at Bear Creek Weir by Weekly Periods, 1981.

Weekly Periods	Number of Smolts		Total
	Live	Dead	
May 13 - May 19	30	9	39
May 20 - May 26	104	19	123
May 27 - June 2	390	49	439
June 3 - June 9	10,758	18	10,776
June 10 - June 16	28,225	33	28,258
June 17 - June 23	18,806	74	18,880
June 24 - June 30	4,658	18	4,676
July 1 - July 7	6,336	15	6,351
July 8 - July 14	2,034	7	2,041
July 15 - July 21	265	8	273
July 22 - July 28	68	3	71
July 29 - August 4	20	5	25
August 5 - August 11	39	1	40
August 12 - September 22	0	0	0
September 12 - September 29	<u>890</u>	<u>6</u>	<u>896</u>
Total	72,623	265*	72,888

* Includes 102 smolts sampled for foregut analysis by F.R.E.D. Division's Limnology section.

Table 3. Bear Lake Coho Salmon Smolts Marked and Sampled at Bear Creek Weir by Weekly Period, 1981.

Weekly Period	Number of Live Smolts	Number Smolts Fin Clipped	Percent of Weekly Migration*	Number Smolts Sampled	Percent of Weekly Migration*
May 13 - 26**	134			7	5.2
May 27 - June 2	390	201	51.5	6	1.4
June 3 - 9	10,758	2,588	24.0	107	1.0
June 10 - 16	28,225	7,049	25.0	282	1.0
June 17 - 23	18,806	4,740	25.2	156	0.8
June 24 - 30	4,658	1,347	28.9	50	1.1
July 1 - 7	6,336	1,638	25.9	55	0.9
July 8 - 14	2,034	263	12.9	16	0.8
July 15 - 21	265	99	37.4	2	0.8
July 22 - 28	68	38	55.9	1	1.5
July 29 - August 4	20	4	25.0	1	5.0
August 5 - 11	39	10	25.6		
August 12 - Sept. 22	0				
Sept. 23 - 29	890				
Total	72,623	17,977	24.8	683	0.9

* Minus the 265 smolts expiring from trap mortality.

** Seven smolts (5.2% of out-migration) were sampled from May 13 - 26.

Table 4. Mean Fork Length, Weight and Condition Factor of Age 1.0 Bear Lake Coho Salmon Smolts Sampled Weekly at Bear Creek Weir, 1981.

Weekly Periods	Number of Smolts	Percent of Sample	Mean Length (mm) \pm SD	Mean Weight (g) \pm SD	Condition Factor (K)*
May 13 - 19	3	100.0	107.3 \pm 3.1	12.90 \pm 1.50	1.04
May 20 - 26	3	75.0	107.0 \pm 6.9	11.20 \pm 2.62	0.91
May 27 - June 2	2	33.3	102.5 \pm 4.9	10.95 \pm 1.48	1.02
June 3 - 9	13	12.1	115.9 \pm 2.7	15.42 \pm 2.67	0.99
June 10 - 16	29	10.3	116.5 \pm 7.5	16.22 \pm 3.02	1.03
June 17 - 23	25	16.0	121.5 \pm 8.5	18.44 \pm 3.29	1.03
June 24 - 30	12	24.0	122.7 \pm 9.2	20.03 \pm 4.13	1.08
July 1 - 7	14	25.5	122.6 \pm 16.8	20.98 \pm 6.83	1.14
July 8 - 14	4	26.7	130.8 \pm 6.1	24.35 \pm 2.75	1.09

* $K = \frac{W \times 10^5}{L^3}$, where W = mean weight in grams, and L = mean fork length in millimeters.

Table 5. Mean Fork Length, Weight and Condition Factor of Age 2.0 Bear Lake Coho Salmon Smolts Sampled Weekly at Bear Creek Weir, 1981.

Weekly Periods	Number of Smolts	Percent of Sample	Mean Length (mm) \pm SD	Mean Weight (g) \pm SD	Condition Factor (K)*
May 20 - 26	1	25.0	165.0	48.50	1.08
May 27 - June 2	4	66.7	137.3 \pm 9.5	26.75 \pm 5.59	1.03
June 3 - 9	93	86.9	128.3 \pm 10.0	21.68 \pm 5.22	1.03
June 10 - 16	253	89.7	127.0 \pm 9.1	19.76 \pm 10.50	0.96
June 17 - 23	131	84.0	128.4 \pm 8.2	21.76 \pm 3.85	1.03
June 24 - 30	38	76.0	131.2 \pm 9.0	24.24 \pm 4.64	1.07
July 1 - 7	41	74.5	139.5 \pm 7.4	28.87 \pm 4.18	1.06
July 8 - 14	11	73.3	136.7 \pm 9.0	28.05 \pm 5.92	1.10
July 15 - 21	2	100.0	140.0 \pm 8.5	30.80 \pm 3.25	1.12
July 22 - 28	1	100.0	134.0	28.70	1.19
July 29 - Aug. 4	1	100.0	168.0	53.90	1.14

* $K = \frac{W \times 10^5}{L^3}$, where W = mean weight in grams, and L = mean fork length in millimeters.

Table 6. Relative Abundance and Timing of Age 1.0, 2.0 and 3.0 Bear Lake Coho Salmon Smolts Migrating to Bear Creek Weir, 1981.

Weekly Periods	Number of Smolts			Total
	Age 1.0	Age 2.0	Age 3.0	
May 13 - 19	39			39
May 20 - 26	92	31		123
May 27 - June 2	146	293		439
June 3 - 9	1,304	9,364	108	10,776
June 10 - 16	2,911	25,347		28,258
June 17 - 23	3,021	15,859		18,880
June 24 - 30	1,122	3,554		4,676
July 1 - 7	1,620	4,731		6,351
July 8 - 14	510	1,403	128	2,041
July 15 - 21		273		273
July 22 - 28		71		71
July 29 - August 4		25		25
August 5 - 11		40		40
August 12 - Sept. 22	0	0		0
September 23 - 29*	<u>134</u>	<u>759</u>	<u>3</u>	<u>896</u>
Total	10,899	61,750	239	72,888
Percent	15.0	84.7	0.3	100.0

* Number of smolts per age group for September 23 - 29 is estimated by overall age composition (15.0% Age 1.0, 84.7% Age 2.0, and 0.3% Age 3.0) determined up to that point.

Age 1.0, 17.2% Age 2.0 and 0.2% Age 3.0. Bear Lake coho salmon fingerling plants since 1977 are summarized in Table 7 and smolt production since 1978 is presented in Table 8.

The 61,750 Age 2.0 smolts were produced from 225,500 Age 0.0 fingerlings stocked in 1979. With the 54,580 Age 1.0 smolts which emigrated in 1980, 51.6% of that plant has survived to smolts thus far. This is the second highest percentage of any Bear Lake fingerling release resulting in smolts in the project's 19-year history. However, the latter is overshadowed by the fact that most of this smolt production cycle thus far (minus Age 3.0 smolts in 1982) is comprised of Age 2.0 smolts. Excepting Age 3.0 smolt production from this plant in 1982, age composition of Bear Lake's eighth smolt production cycle since the 1971 lake rehabilitation was 46.9% Age 1.0 and 53.1% Age 2.0.

The 10,899 Age 1.0 smolts survived from 150,000 Age 0.0 fingerlings released in Bear Lake in 1980. This plant was the smallest made since the 1971 lake rehabilitation due to failure to obtain the coho salmon egg quota in 1979 (McHenry, 1980) and the consequent unavailability of fingerlings in 1980. The resultant further reduction in stocking density (337/acre vs. 500/acre) theoretically should have allowed a relatively large portion of this sparse fingerling release to emigrate as Age 1.0 smolts. However, only 7.3% of this plant produced yearling smolts, despite the fairly large size (246/lb) of the fingerlings at time of release. The presence of the above Age 2.0 smolts and an unknown abundance of Age 2.0 residuals in Bear Lake concurrent with timing of the 1980 fingerling release may have had a deleterious effect on the latter's survival (McHenry, 1981) due either to predation or competition, or both. Age 2.0 smolt abundance in 1982 will depend upon the extent of Age 1.0 residualism and overwinter survival of the 1980 fingerling plant.

Age 1.0 smolts averaged 121.5 mm and 18.44 g for a condition factor (K) of 1.03 at migration peak on June 17-23. Growth of the 1980 Age 0.0 fingerlings surviving to yearling smolts appeared to be good, considering they averaged 55 mm and 1.84 g at release in Bear Lake 1 year earlier. In contrast, Age 2.0 smolts were 7.8 mm and 4.28 g smaller than this age group at migration peak on June 10-16 in 1980. Age 2.0 smolts averaged 127.0 mm and 19.76 g for a K=0.96 in 1981. The two Age 3.0 smolts sampled averaged 161.5 mm and 42.55 g for a K=1.01.

Bear Lake's estimated smolt biomass production in 1981 was 1,551.7 kg, or 13.6 kg less than that produced in 1980. As in 1980, the lowered abundance of Age 1.0 smolts was solely responsible for the current reduction in Bear Lake's smolt biomass. Table 9 summarizes total numbers of smolts, estimated annual biomass and seasonal condition factor of Bear Lake smolt migrations since 1973. Compared to the 7-year (1973-1979) average of 102,026 smolts comprising 2,166.2 kg biomass, the 1981 Bear Lake production was down by 29,138 smolts and 614.5 kg (1,354.7 lb).

Bear Lake was restocked on June 2, 1981 with 247,845 Age 0.0 coho salmon fingerlings (1980 brood, Bear Lake origin) averaging 749/kg (340/lb) to maintain smolt production.

Table 7. Summary of Bear Lake Coho Salmon Fingerling Plants, 1977 - 1981.

Brood Year	Source of Eggs	No. Fish Stocked	Weight		Size*		Density		Date of Plants	Planting Method
			lbs	kg	No./lb	No./kg	No./acre	No./ha		
1976	Bear Lake	<u>227,700</u>	<u>780</u>	<u>353.8</u>	<u>292</u>	<u>644</u>	<u>512</u>	<u>1,264</u>	June 16 1977	Truck-boat Scattered
1977	Bear Lake	157,000	457	207.3	345	757	353	871	June 20	Truck-boat
	Bear Lake	<u>68,800</u>	<u>216</u>	<u>98.0</u>	<u>320</u>	<u>705</u>	<u>154</u>	<u>382</u>	June 20	Scattered
	Total	<u>225,800</u>	<u>673</u>	<u>305.3</u>	<u>337</u>	<u>743</u>	<u>507</u>	<u>1,253</u>	1978	
1978	Bear Lake	<u>225,500</u>	<u>340</u>	<u>154.2</u>	<u>663</u>	<u>1,462</u>	<u>507</u>	<u>1,253</u>	May 24 1979	Aircraft Scattered
1979	Bear Lake	134,375	542	245.8	248	546	302	746	June 12	Aircraft
	Bear Lake	<u>15,625</u>	<u>68</u>	<u>30.8</u>	<u>231</u>	<u>508</u>	<u>35</u>	<u>86</u>	June 18	Aircraft
	Total	<u>150,000</u>	<u>610</u>	<u>276.6</u>	<u>246</u>	<u>542</u>	<u>337</u>	<u>832</u>	1980	Scattered
1980	Bear Lake	143,427	439	198.9	327	716	322	796	June 2	
	Bear Lake	<u>104,418</u>	<u>291</u>	<u>131.9</u>	<u>359</u>	<u>792</u>	<u>235</u>	<u>580</u>	June 2	Truck-boat
	Total	<u>247,845</u>	<u>730</u>	<u>330.8</u>	<u>340</u>	<u>749</u>	<u>557</u>	<u>1,376</u>	1981	Scattered

* Weighted averages.

Table 8. Summary of Bear Lake Coho Salmon Smolt Abundance and Biomass Produced Since 1978 from Annual Fingerling Plants, 1977 - 1980.

Year of Plant	No. of Fingerling and Weight (kg)	Smolt Production by Year				Total Production	Survival to Smolt (%)
		1978	1979	1980	1981		
<hr/>							
<u>1977</u>							
Number	227,700	81,014	8,172	106		89,292	39.2
Weight (kg)	353.8	1,422.8	255.0	7.2		1,685.0	
Weight Ratio		4.0:1	0.7:1	0.0:1		4.8:1	
<u>1978</u>							
Number	225,800		97,144	20,294	239	117,677	52.1
Weight (kg)	305.3		1,808.0	504.8	10.2	2,323.0	
Weight Ratio			5.9:1	1.7:1	0.0:1	7.6:1	
<u>1979</u>							
Number	225,500			54,580	61,750	116,330	51.6*
Weight (kg)	154.2			1,053.3	1,348.7	2,402.0	
Weight Ratio				6.8:1	8.7:1	15.6:1	
<u>1980</u>							
Number	150,000				10,899		7.3**
Weight (kg)	276.6				192.8		
Weight Ratio					0.7:1		

* Does not include Age 3.0 smolt production.

** Includes only Age 1.0 smolt production.

Table 9. Summary of Abundance, Total Annual Biomass and Seasonal Condition Factor of Bear Lake Smolt Migrations, 1973 - 1981.

Year	Total No. of Smolts	Condition Factor (K)	Total Biomass (kg)
1973	77,343	1.06	2,149.3
1974	72,389	0.93	1,743.2
1975	168,036	0.89	3,381.3
1976	93,311	1.07	2,016.8
1977	99,970	1.03	1,940.2
1978	97,814	0.99	1,869.3
1979	105,316	1.05	2,063.0
1980	74,980	1.01	1,565.3
1981	<u>72,888</u>	<u>1.04</u>	<u>1,551.7</u>
Average (1973-79)	102,026	1.01	2,166.2

Other Species

The total sockeye salmon smolt out-migration enumerated from the trap was 3,485 fish. The first smolt was captured on May 13 and the last on August 4. The highest daily count occurred on May 28 when 1,179 smolts (33.8% of the migration) were enumerated. The majority (94.7%) emigrated between May 13 and June 16, when Bear Creek water temperatures ranged from 3.9°C to 15.0°C (39°F-59°F) and stream flows from 29 to 80 cfs. The smolt out-migration was comprised of 2,805 (80.5%) Age 1.0 and 680 (19.5%) Age 2.0 smolts. Age 2.0 smolts were produced from the 18 females and nine males that spawned in 1978. With the 3,374 Age 1.0 smolts estimated in 1980, a total of 4,054 smolts (225.2 per female) have resulted from this meager escapement. Age 1.0 smolts resulted from only six males and six females in the 1979 escapement. Evidently, spawning success was high despite so few fish comprising the run, with 113.3 smolts produced per female thus far. Both age groups peaked (50% of migration) during May 27-June 2. Age 1.0 smolts averaged 116.9 mm and 16.24 g for a condition factor $K=1.02$, and Age 2.0 smolts 157.6 mm and 41.58 g for $K=1.06$ at migration peak.

A total of 211 Dolly Varden was captured in the downstream trap and released below the weir. No threespine stickleback were caught in the trap or observed in Bear Lake during the field season.

Resurrection Bay Coho Salmon Harvest and Effort

A stratified, random creel census to determine the Resurrection Bay coho salmon sport harvest and effort was initiated at the Seward small boat harbor on July 8 and terminated September 8. Few coho salmon were taken before creel census began since most sport fishing effort was directed toward the more abundant rockfish, Sebastes sp., from mid-May through early July.

The season's total harvest was an estimated 15,743 coho salmon. This estimate was extrapolated from interviews with 4,236 anglers harvesting 2,763 coho salmon during the creel census period. Peak of the harvest occurred on August 9, the second day of the Seward Silver Salmon Derby, when an estimated 934 coho salmon (5.9% of the season's harvest) were taken. The season's total and derby harvests are summarized for 1977 through 1981 in Table 10. Marked adult coho salmon contributed 0.8% or an estimated 131 fish, to the 1981 Resurrection Bay sport harvest. An additional 1,652 unmarked coho salmon resulting from the unmarked segments of hatchery smolt releases and the Bear Lake smolt out-migration in 1980 comprised an estimated 10.5% to the sport catch. The total contribution of enhanced adult coho salmon production, therefore, was 1,783 fish or 11.3% to the sport fishery.

The Ad-CWT marked adult coho salmon survived from 42,440 Ad-CWT marked, Age 0.0 (1979 brood, Bear Lake origin) hatchery-reared coho salmon smolts released in Seward Lagoon (26,860) and Grouse Lake (15,580) in June 1980. The RV marked coho salmon were produced by 18,377 Bear Lake smolts marked at Bear Creek weir. Unmarked hatchery coho salmon resulted from 124,230 unmarked smolts (same brood and origin) stocked in Seward Lagoon (73,940) and Grouse Lake (50,290) with the marked smolts. Additional unmarked coho salmon survived from 56,545 Bear Lake smolts released unmarked past Bear

Table 10. Derby and Total Sport Harvest of Coho Salmon in Resurrection Bay, 1977 - 1981.

Year	Total Sport Harvest	Derby Harvest	% Derby Harvest
1977	16,345	6,007	36.8
1978	15,550	7,258	46.7
1979	17,785	6,073	34.1
1980	20,981	6,732	32.1
1981	15,743	4,758	30.2

Creek weir in 1980. A total of 40,405 Ad-CWT marked, Age 0.0 (1980 brood, Bear Lake origin) hatchery coho salmon smolts were stocked in Seward Lagoon (25,940) and lower Bear Creek (15,465) on June 15-17, 1981. An additional 122,395 unmarked hatchery smolts (same brood year and origin) were released in Seward Lagoon (38,760) and Bear Creek (39,635) with the marked smolts. These plants were comprised of considerably larger smolts (18.0 g or 25/lb) compared to those made in 1980 (11.5-13.3 g or 39-34/lb), so should realize better smolt-to-adult survival. Age 0.1 marked Ad-CWT and unmarked adults surviving from these smolt releases will return in 1982. Also to return in 1982 will be Age 1.1 Ad-CWT and unmarked adults from the "holdover" portions of the 1980 Age 0.0 smolt plants in Seward Lagoon and Grouse Lake which did not emigrate until the spring of 1981.

The total sport fishing effort exerted for Resurrection Bay coho salmon was an estimated 22,937 man-days. An 18.5% sampling of the season's effort was conducted during the creel census period. The mean number and percentage of sport fishing boats returning daily to the Seward small boat harbor are shown in Table 11. The average numbers of anglers per boat were as follows: weekdays, 3.02; weekends, 3.07; and salmon derby, 3.19. Fishing effort and mean seasonal catch per hour are summarized for 1977-1981 in Table 12. The fishing effort was 7,917 man-days on weekdays and 7,087 on weekends, excluding the derby (7,933 man-days). Military personnel and dependents, fishing on boats provided by the Army and Air Force recreation camps at Seward, contributed 14.8% (3,398 man-days) to the total effort. Civilian anglers fishing on weekdays realized the highest coho salmon catch per hour (0.204), whereas the lowest catch rate (0.055) occurred during the derby when effort was more intense. The average number of hours anglers fished per day were as follows: weekdays, 4.52; weekends, 4.71; and salmon derby, 5.90.

An estimated 184 chinook salmon were harvested during the census period at an average of only 0.02 per boat. This harvest was substantially (371 fish) below the 20-year average (1961-1980) catch of this species in Resurrection Bay. Chinook salmon were most abundant during July 8-14 when anglers averaged 0.03 chinook salmon per boat. Most fish taken were immature chinook salmon in their first and second "ocean" years. Origins of these stocks are unknown as chinook salmon rarely ascend Resurrection Bay streams. A total of 32 adult and 13 jack chinook salmon returned to Box Canyon Creek from three annual (1977-1979) smolt releases in that tributary, according to a foot survey conducted on August 17. Of the 29 carcasses examined, three were fin-marked RV, five were Ad-CWT marked and 21 were unmarked. Size composition of the Ad-CWT and unmarked carcasses indicated that two-thirds were Age 0.3 adults and one-third Age 0.2 jacks. Therefore, the escapement was estimated to be comprised of five Age 0.4 fish surviving from 50,000 RV-marked smolts released in 1977, 27 Age 0.3 adults from 150,500 smolts stocked in 1978, and 13 Age 0.2 jacks from 218,500 smolts planted in 1979. No fin-marked chinook salmon were observed in the sport harvest during creel census. Total smolt-to-adult survivals of the 1976 (27,100 smolts) and 1977 smolt releases in Box Canyon Creek were estimated at 0.06% and 0.04%, respectively. This program was discontinued after 1979 due to the negligible returns obvious at that time.

The Resurrection Bay pink salmon sport catch in 1981 (8,986 fish) was second only to the record harvest of 13,292 pink salmon in 1980. A limited commercial fishery conducted on July 31 through August 1 (48 hours) and

Table 11. Mean Number and Percentage of Sport Fishing Boats Returning to the Seward Small Boat Harbor During Each Sampling Period, 1981.

Periods (hours)	Weekends		Weekdays	
	Mean No. of Boats	Percent	Mean No. of Boats	Percent
8:00 a.m. - 11:30 a.m.*	14.8	11.6	7.0	14.3
11:30 a.m. - 3:00 p.m.	39.1	30.7	11.8	24.2
3:00 p.m. - 6:30 p.m.	57.1	44.8	19.3	39.7
6:30 p.m. - 10:00 p.m.	<u>16.5</u>	<u>12.9</u>	<u>10.6</u>	<u>21.8</u>
Total	127.5	100.0	48.7	100.0

* Percentage for this period determined by three-year mean, 1964-1966.

Table 12. Derby and Total Sport Effort (Man-Days) Exerted for Coho Salmon and Mean Catch Per Hour in Resurrection Bay, 1977 - 1981.

Year	Period of Census	Total Effort	Derby Effort	% Derby Effort	Seasonal Catch Per Hour
1977	July 9 - Sept. 7	23,997	9,121	38.0	0.113
1978	July 8 - Sept. 10	22,291	10,064	45.1	0.126
1979	July 8 - Sept. 9	24,651	8,280	33.6	0.131
1980	July 8 - Sept. 7	25,527	8,886	34.8	0.145
1981	July 8 - Sept. 8	22,937	7,933	34.6	0.122

August 4 (4 hours) by six seine boats, harvested 32,000 pink salmon (Schroeder, pers. comm.). This was the first odd-year commercial season opening since 1967 due to the abnormally strong run, reflected by very high weekly sport catch rates in July. Pink salmon were most abundant in the sport fishery from early July through early August when anglers averaged 2.97 fish per boat. Pink salmon catch per man-day averaged 0.31 in 1981, compared to 0.11 in 1979, the parent brood year which produced the 1981 return.

Bear Lake Upstream Migration

The Bear Creek weir upstream migrant trap was operated continuously from May 16 through November 13. The first adult coho salmon entered the trap on August 11 and the last one was captured November 11. A total of 431 coho salmon spawned in lower Bear Creek after the adult run had entered the trap, according to a foot survey conducted on November 9.

A total of 3,924 adults and 16 jacks were enumerated from the trap. Abundance and timing of the adult coho salmon migration are shown in Table 13. Weekly breakdown by marked release lot is presented in Table 14. The adult migration peaked (50%) on September 20, and the highest daily count of 185 (4.7% of the adult run) occurred on September 21. Mean stream temperatures at the beginning, peak and end of the migration were 14.4°C (58.0°F), 10.8°C (51.5°F) and 1.9°C (35.5°F), respectively. Most of the migration (74.6%) occurred from August 26 through October 27 when Bear Creek temperatures ranged from 3.3°C to 13.9°C (38°F - 57°F) and flows from 18 to 84 cfs. Most (96.3%) of the marked coho salmon escapement to the weir returned from 17,977 Age 1.0, 2.0 and 3.0 Bear Lake smolts marked with an RV fin clip at Bear Creek weir in 1980. Six LV marked adults, probably resulting from 1980 Bear Lake smolts fin-clipped on the wrong side, were also enumerated from the trap.

With the additional 80 coho salmon estimated taken in the Resurrection Bay boat fishery, seven caught in the beach fishery and 27 strays estimated in local tributaries, the total return of the marked Bear Lake lot was only 304 fish (1.65% smolt-to-adult survival). In contrast, an estimated 5,652 unmarked adult coho salmon survived from the 56,545 Bear Lake smolts released unmarked past the weir in 1980. Total smolt-to-adult survival of this lot was 10.0%. Table 15 shows the various run components comprising total adult returns of the Bear Lake, Grouse Lake and Seward Lagoon production from 1980 smolt releases.

The one Ad-CWT marked adult coho salmon captured in the upstream trap and eight Ad-CWT fish estimated spawning in lower Bear Creek probably strayed into Bear Creek from the Grouse Lake return of hatchery coho salmon. No Ad-CWT hatchery-reared smolts were released in Bear Creek below the weir in 1980.

Analysis of 681 scale samples representatively sampled from the Bear Lake unmarked escapement disclosed that the return was comprised of 3,261 Age 1.1 (57.7%), 2,334 Age 2.1 (41.3%) and 57 (1.0%) Age 3.1 adults. This extrapolation includes the 423 unmarked adults estimated spawning in lower Bear Creek. The adult age composition, therefore, translates to 1980 Bear Lake smolt-to-adult survivals of 5.98%, 11.51% and 53.77% for Age 1.0, 2.0 and 3.0 smolts, respectively. The Age 3.0 smolt-to-adult survival appears

Table 13. Bear Lake Adult Coho Salmon Enumerated Through Bear Creek Weir by Weekly Periods, 1981.

Weekly Periods	Marked	Unmarked*	Male	Female	Total
August 5 - 11		2	1	1	2
August 12 - 18		4	4		4
August 19 - 25	3	41	30	14	44
Aug. 26 - Sept. 1	7	362	241	128	369
Sept. 2 - 8	19	445	305	159	464
Sept. 9 - 15	39	597	395	241	636
Sept. 16 - 22	58	777	562	273	835
Sept. 23 - 29	13	288	201	100	301
Sept. 30 - Oct. 6	6	168	95	79	174
Oct. 7 - 13	16	214	122	108	230
Oct. 14 - 20	15	314	206	123	329
Oct. 21 - 27	15	410	237	188	425
Oct. 28 - Nov. 3		79	39	40	79
Nov. 4 - 10		3	2	1	3
Nov. 11 - 17	<u> </u>	<u>29</u>	<u>18</u>	<u>11</u>	<u>29</u>
Total	191	3,733	2,458	1,466	3,924

* Approximately 75% of the 1980 Bear Lake smolt out-migration was released unmarked to enhance smolt-to-adult survival.

Table 14. Marked Adult Coho Salmon Enumerated Through Bear Creek Weir by Weekly Periods, 1981.

Weekly Periods	Marked (Fin-clip)*			Total
	Ad-CWT	RV	LV	
August 19 - 25		3		3
Aug. 26 - Sept. 1		6	1	7
Sept. 2 - 8		18	1	19
Sept. 9 - 15	1	37	1	39
Sept. 16 - 22		56	2	58
Sept. 23 - 29		13		13
Sept. 30 - Oct. 6		5	1	6
Oct. 7 - 13		16		16
Oct. 14 - 20		15		15
Oct. 21 - 27		<u>15</u>		<u>15</u>
Total	1	184	6	191

* Ad-CWT (adipose-coded wire tag) - Probably a stray from the Grouse Lake return.

RV (right ventral) - 1980 Bear Lake smolts marked (24.5%) at Bear Creek weir.

LV (left ventral) - Probably 1980 Bear Lake smolts fin-clipped on wrong side.

Table 15. Estimated Adult Return Components of Bear Lake, Grouse Lake and Seward Lagoon Enhanced Coho Salmon Production from 1980 Smolt Releases.

Water Body and Fin Mark	Boat Harvest*	Beach Harvest**	Escapement	Strays	Total Return	Smolt-to-Adult Survival (%)
Bear Lake***						
RV	66		184	27		
LV	14	7	6		304	1.65
UNM	1,496		4,156		5,652	10.00
Grouse Lake						
Ad-CWT	25	2	9	14	50	0.32
UNM	64	7	63		134	0.39
Seward Lagoon						
Ad-CWT	26	6	19		51	0.19
UNM	<u>92</u>	<u>21</u>	<u>90</u>	<u>—</u>	<u>203</u>	<u>0.27</u>
Total						
Marked	131	15	218	41	405	0.67
UNM	1,652	28	4,309		5,989	3.63

* Boat harvests of Ad-CWT coho were apportioned according to relative abundance of Ad-CWT escapements (including beach harvest and strays) estimated for each system. Boat harvests of unmarked (UNM) hatchery coho were apportioned according to UNM escapements estimated by Ad-CWT smolt-to-adult survivals per system.

** Beach harvests of Grouse Lake and Seward Lagoon hatchery coho were estimated after apportioning 74% (1973-1978 average) of the total beach harvest to the Seward Lagoon return.

*** Boat harvest of UNM Bear Lake coho was estimated by applying the 0.36:1 catch: escapement ratio of the RV and LV marked fish (combined) to the UNM Bear Lake escapement.

to be highly exaggerated, probably due either to underestimating abundance of Age 3.0 smolts in the 1980 out-migration or unestimated natural production of this smolt age class in lower Bear Creek.

Mean fork length and weight of adult coho salmon sampled at the weir are presented in Table 16. The 1981 adult size composition indicated a slight increase (18 mm and 0.4 kg) in ocean growth over that of the 1980 Bear Lake coho salmon return. The male:female sex ratio, excluding jacks, was 1.7:1 in the Bear Creek escapement.

Only 16 unmarked jacks were enumerated from the trap and probably returned prematurely from the unmarked segment (54,646 smolts) of the 1981 Bear Lake smolt out-migration passed downstream. The 39,635 unmarked Age 0.0 (1980 brood, Bear Lake origin), hatchery-reared smolts released below the weir were slightly smaller (25.5/lb vs. 21.3/lb) than Bear Lake smolts in 1981. An additional 14,465 (26.7% of the plant) Ad-CWT marked hatchery smolts (same brood and origin) were stocked in lower Bear Creek with the unmarked fish. This hatchery smolt release, originally scheduled for Grouse Lake, was instead transferred to lower Bear Creek because of the paucity in Bear Lake's smolt out-migration and to ensure adequate adult escapement to the weir for the 1982 Southcentral egg take requirement.

Coho Salmon Egg-Takes

A total of 197 males and 639 females were held in the Bear Creek holding facility from September 1 to November 6. Stream temperatures ranged from 1.7°C to 13.9°C (35°F - 57°F), and flows from 18 to 84 cfs during this period. Male and female holding mortalities were 20.8% and 18.6%, respectively. A total of 472 females and 135 males were artificially spawned, yielding an estimated 2,003,800 fertilized eggs. Mean fecundity was 4,245 eggs per female, or nearly 300 higher than that obtained (3,967) from females in 1980. Eggs were fertilized at an average rate of 1 male:3.5 females. Dead egg loss after physical shocking at Elmendorf Hatchery averaged 5.4% (Ohlinger, pers. comm.) through "eyed" stage.

Assistance was again provided to Dr. Joseph Sullivan, Division of F.R.E.D. pathologist, in conducting an experiment to determine the extent Bear Lake coho salmon were infected with bacterial kidney disease (BKD), Renibacterium salmoninarum, and whether immersing the eggs after immediate fertilization at the weir or delayed fertilization at the hatchery with erythromycin-phosphate (EryPO₄) antibiotic would eradicate the disease. A 6% incidence of BKD was detected in pathological examination of 60 Bear Lake coho salmon (spawned carcasses) during an egg take on October 16, 1981 (Wall, pers. comm.).

The 442,000 eggs artificially spawned on October 16 were split up into four experimental lots of approximately 110,000 each. Of the two lots fertilized at the weir, the control (water-hardened only) had a 96.5% survival to eyed stage and the EryPO₄ treated group realized 93.8% survival. Survival of the EryPO₄ treated, delayed fertilization lot at Elmendorf Hatchery was virtually identical (93.0%) to the latter, while that (79.0%) of the control group was considerably lower. Inadequate washing/water hardening of the eggs in that group probably was responsible for the relatively lower survival to eyed stage (Krolick, pers. comm.). Therefore, from these findings, it appears that immediate fertilization at the weir is

Table 16. Mean Fork Length (mm) and Weight (kg) of Adult Coho Salmon Sampled at Bear Creek Weir in 1980.

Lot	Males			Females			Sexes Combined		
	No.	FL	Wt.	No.	FL	Wt.	No.	FL	Wt.
LV	2	638.5	3.11				2	638.5	3.11
RV	23	672.5	3.69	17	667.5	3.91	40	670.4	3.78
UNM	<u>396</u>	<u>676.8</u>	<u>3.79</u>	<u>286</u>	<u>674.3</u>	<u>3.92</u>	<u>682</u>	<u>675.8</u>	<u>3.85</u>
Total	421	676.4	3.78	303	674.0	3.92	724	675.4	3.84

preferable and treating the eggs with EryPO₄ antibiotic makes no difference in survival (Sullivan, pers. comm.). Of 50 eggs subsampled from each of the four experimental lots, all appeared to have been fertilized with embryonic development progressing at the same rate (Burke, pers. comm.). Follow-up observations will be conducted on resultant hatched fry and rearing fingerlings to smolt stage for presence of BKD. Currently, incubation and rearing of Bear Lake stock coho salmon in the Fort Richardson Hatchery is prohibited due to the confirmed incidence of BKD and the potential for contaminating other hatchery fish.

Other Species

A total of 694 adult sockeye salmon were captured in the upstream migrant trap from June 2 to July 22. Most adults (89.6%) were Age 1.3, surviving from 11,670 Age 1.0 smolts that emigrated from Bear Lake in 1978. With the six Age 1.1 jacks, 1,455 Age 1.2 and 622 Age 1.3 adults estimated in 1979, 1980 and 1981, respectively, total smolt-to-adult survival of this cycle is 17.8%. One Age 2.3 adult detected in the population sample (n=134) had apparently strayed into Bear Creek from the Grouse Creek spawning escapement, since no smolts were produced by the 1975 parent brood year escapement (seven age 1.1 jacks only) in Bear Lake. An estimated 71 Age 2.2 adults (10.2% of the run) returned from 701 Age 2.0 smolts which emigrated from Bear Lake in 1979. Including the two Age 2.1 jacks observed in the 1980 Bear Lake escapement, smolt-to-adult survival thus far is 10.4%. Three-ocean adults are expected to return from the 1979 smolt out-migration in 1982. Mean sizes of Age 1.3 and 2.2 fish were 602.0 mm in fork length (2.78 kg weight) and 553.9 mm (2.12 kg), respectively.

Nine adult chinook salmon were observed spawning in lower Bear Creek on July 28. These fish probably resulted from hatchery-reared chinook salmon fingerlings or smolts mixed in with coho salmon released in Bear Lake or Bear Creek in recent years. This species is rarely observed in Bear Creek.

The first pink salmon entered the trap on July 27, and the 425 (Schroeder, pers. comm.) comprising the escapement spawned in lower Bear Creek during late August/early September.

Upstream migrating Dolly Varden ascended Bear Creek to the weir in mid-July and continued moving in and out of the trap throughout the remaining field season. All fish species other than sockeye or coho salmon were retained below the weir due to the lack of suitable spawning area upstream and/or the undesirability of having those species depredating or competing with juvenile salmon in Bear Lake for survival.

Bear Lake Fertilization Project

It may be possible to increase Bear Lake's carrying capacity of juvenile coho salmon via artificial fertilization of its rearing environment. Division of F.R.E.D.'s Limnology Section has collected data on Bear Lake's water chemistry, primary productivity levels, benthic communities and zooplankton populations for the past 3 years to determine the feasibility of conducting such an experiment. The Bear Lake prefertilization report concluded that Bear Lake is now producing mostly "dead-end" species of blue-green algal phytoplankton which are not utilized by the zooplankters (mainly cladocerans) that juvenile salmon prey upon. Water chemistry data

indicated Bear Lake has an unbalanced nitrogen:phosphorus ratio (in favor of the latter) which is conducive to blue-green algal production. Therefore, the report recommended Bear Lake be treated with ammonium-nitrate (NH_4NO_3) liquid fertilizer to reverse its trend of contributing unusable phytoplankton to the salmonid food chain. Ninety 30-gallon barrels of fertilizer, an applicator pump, and storage area in a heated warehouse from freeze-up to ice-out to prevent crystallization of the fertilizer were purchased with \$10,000 from the Seward Salmon Derby Fish Restoration Fund. Considerable logistical support, coordination and assistance was provided to the Division of F.R.E.D. personnel in transporting the fertilizer from Seward and dispersing it in Bear Lake. Nearly half (1,320 gallons) of the fertilizer shipment was uniformly distributed on the surface of Bear Lake's northern portion from early September to late October, through fall overturn. Monitoring of Bear Lake's water quality parameters continued until freeze-up in mid-November. The remaining fertilizer (1,380 gallons) will be spread in Bear Lake's southern half from ice-out through early summer.

Enhanced Coho Salmon Production

Marked (Ad-CWT) coho salmon spawning escapements bound for Seward Lagoon and Grouse Lake were estimated at only 25 adults for each system. A total of 211 RV and 13 LV marked coho salmon were estimated in the Bear Lake escapement. Also, unmarked coho salmon escapements attributed to unmarked segments of the 1980 Seward Lagoon, Grouse Lake and Bear Lake smolt releases were 90, 63 and 4,156 adults, respectively. These escapements include strays observed in local index streams and coho salmon estimated taken in the shore fishery after the Resurrection Bay sport-trolling effort terminated (Table 15). Overall smolt-to-adult survival of marked and unmarked Bear Lake smolts was 7.95%, or 2.81% higher than that realized for the 1979 out-migration. It is noted that Bear Lake smolts in 1980 were slightly larger (21.8/lb) than smolts in 1979 (23.3/lb) despite that their average condition factor was lower ($K=1.01$) than that of the 1979 smolts ($K=1.05$). Total estimated smolt-to-adult survivals of the Grouse Lake and Seward Lagoon hatchery smolt lots, however, were only 0.37% and 0.25%, respectively. These poor survivals resulted because of the small size of the "0-Age" smolts when stocked in these waters in 1980. The Grouse Lake and Seward Lagoon smolts averaged 34.0/lb and 39.1/lb, respectively, at release.

Summaries of total survivals for Bear Lake, Seward Lagoon, Bear Creek and Grouse Lake smolt releases are presented in Tables 17, 18, 19 and 20, respectively.

DISCUSSION

Although Bear Lake's smolt-to-adult survivals have increased 60% due to healthier, more robust smolts resulting from reduced fingerling stocking densities since 1976, there are recent indications of declining smolt productivity in Bear Lake: (1) yearling (Age 1.0) smolt yields from the 1979 and 1980 Age 0.0 fingerling plants have dropped from 43% (1978 release) to 24% and 7%, respectively; (2) Age 1.0 residualism of too small (663/lb) fingerlings planted in 1979 not only produced mainly (53%) Age 2.0 smolts, but also adversely affected Age 1.0 smolt survival of the 1980

Table 17. Survival of Bear Lake Coho Salmon Adults from Seaward Migrations of Smolts Fin Marked at Bear Creek Weir, 1975 - 1979.

Seaward Migration Year	Number of Smolts Released	Age Composition of Out-Migration	Mean Fork Length (mm)	Fin-clip Used	Number of Adults Returning*	Percentage Return
1975	11,532 131,180 877 <u>143,589</u>	8.0% - age 1.0 91.4% - age 2.0 0.6% - age 3.0	107.3 129.2 150.7	Ad Ad Ad	1,603	1.12
1976	63,674 28,031 1,010 <u>92,715</u>	68.7% - age 1.0 30.2% - age 2.0 1.1% - age 3.0	106.3 134.9 161.0	Ad-RV Ad-RV Ad-RV	2,674	2.88
1977	49,689 48,332 1,684 139 <u>99,844</u>	49.8% - age 1.0 48.4% - age 2.0 1.7% - age 3.0 0.1% - age 4.0	113.1 129.5 182.8 192.0	Ad-LV Ad-LV Ad-LV Ad-LV	3,835	3.84
1978	80,886 16,431 342 <u>97,659</u>	82.8% - age 1.0 16.8% - age 2.0 0.4% - age 3.0	120.0 134.8 191.7	LV,RV LV,RV LV,RV	3,910	4.00
1979	96,327 8,149 <u>104,476</u>	92.2% - age 1.0 7.8% - age 2.0	120.6 146.2	LV LV	5,368	5.14
1980	54,538 20,278 106 <u>74,922</u>	72.8% - age 1.0 27.1% - age 2.0 0.1% - age 3.0	121.8 134.8 191.0	RV RV RV	5,956	7.95

* Includes boat and shore sport harvest estimates plus escapements.

Table 18. A Summary of Hatchery Reared Coho Salmon Smolt Releases in Seward Lagoon.

Brood Year	Origin	Smolt Liberation Data				Adult Return Data*				Total Number	Return Percent
		Mark	Release Date	Number	Fish/kg(lb)	O+Ocean(jacks) No.	%	1-Ocean No.	%		
1966	Oregon	Ad	4/18-22/68	42,200	40.1 (18.2)	0	0.00	15	0.04	15	0.04
1967	Oregon	Ad	5/6-7/69	27,100	32.2 (14.6)	1	0.00	6	0.02	7	0.03
1968	Bear Lake	Ad	5/19-27/70	39,750	23.8 (10.8)	952	2.39	5,114	12.87	6,066	15.26
1969	Bear Lake	Ad	5/17/71	10,900	31.3 (14.2)	3	0.03	1,519	13.94	1,522	13.96
1970	Kodiak	Ad	5/31/72	66,500	37.0 (16.8)	915	1.38	2,963	4.46	3,878	5.83
1971	Seward Lagoon	Ad-LV	5/7-9/73	30,200	19.6 (8.9)	140	0.46	125	0.41	265	0.88
1972	Kodiak	Ad-RV	5/6-11/74	100,000	20.7 (9.4)	4,764	4.76	3,885	3.89	8,649	8.65
1973	Seward Lagoon	Ad-LV	5/15-19/75	100,700	20.1 (9.1)	2,610	2.59	1,971	1.96	4,581	4.55
1974	Bear Lake	LV	5/4-10/76	100,600	28.2 (12.8)	600	0.60	4,513	4.49	5,113	5.08
1975	Bear Lake	RV	5/6-13/77	100,450	27.7 (10.3)	1,622	1.61	7,710	7.68	9,332	9.29
1976	Seward Lagoon	Ad-CWT	6/1-5/78	125,979	21.7 (9.9)	147	0.12	1,080	0.86	1,227	0.98
1977	Bear Lake	Ad-CWT	5/14-15/79	97,840	63.9 (29.0)	0	0.00	3,956	4.04	3,956	4.04
1979	Bear Lake	Ad-CWT**	6/25/80	100,800	86.1 (39.1)	0	0.00	254	0.25	254	0.25

* Includes boat and shore sport harvest estimates plus escapements.

** Release consisted of 73,940 unmarked (73.4%) and 26,860 marked (26.6%) smolts.

Table 19. A Summary of Hatchery Reared Coho Salmon Smolt Releases in Lower Bear Creek.

Brood Year	Origin	Smolt Liberation Data				Adult Return Data*				Total Return	
		Mark	Release Date	Number	Fish/kg(lb)	O+Ocean(jacks)		l-Ocean		Number	Percent
						No.	%	No.	%		
1967	Oregon	Ad	5/8-13/69	47,470	30.4 (13.8)	8	0.02	17	0.04	25	0.05
1968	Bear Lake	Ad	5/27/70	6,400	22.7 (10.3)	76	1.19	285	4.45	361	5.64
1969	Bear Lake	Ad	5/18-21/71	51,000	31.3 (14.2)	14	0.03	178	0.35	192	0.38
1970	Kodiak	Ad	5/15-24/72	155,500	32.6 (14.8)	155	0.10	470	0.30	625	0.40
1974	Bear Lake	Ad-LV	5/12-14/76	35,600	25.1 (11.4)	16	0.05	756	2.12	772	2.17
1975	Bear Lake	Ad-RV	5/13-15/77	35,100	23.1 (10.5)	436	1.24	1,709	4.87	2,145	6.11
1976	Seward Lagoon	Ad-CWT	5/31/78	28,574	22.2 (10.0)	153	0.54	1,343	4.70	1,496	5.24
1977	Bear Lake	Ad-CWT	5/18/79	40,400	55.1 (25.0)	0	0.00	881	2.18	881	2.18
1979**											

* Includes boat and shore sport harvest estimates.

** No hatchery reared smolts were released in Bear Creek in 1980.

Table 20. A Summary of Hatchery Reared Coho Salmon Smolt Releases in Grouse Lake.

Brood Year	Origin	Smolt Liberation Data				Adult Return Data*				Total Number	Return Percent
		Mark	Release Date	Number	Fish/kg(1b)	0+Ocean(jacks)		1-Ocean			
						No.	%	No.	%		
1974	Bear Lake	RV	5/10-12/76	35,200	26.8 (12.2)	50	0.14	1,498	4.26	1,548	4.40
1975	Bear Lake	LV	5/15-17/77	35,100	22.3 (10.1)	446	1.27	2,304	6.56	2,750	7.83
1976	Seward Lagoon	Ad-CWT	5/30/78	53,555	24.9 (11.3)	118	0.22	801	1.50	919	1.72
1977	Bear Lake	Ad-CWT	5/16/79	44,000	62.6 (28.4)	0	0.00	1,337	3.04	1,337	3.04
1979	Bear Lake	Ad-CWT**	6/26/80	50,290	75.0 (34.0)	0	0.00	184	0.37	184	0.37

* Includes boat and shore sport harvest estimates.

** A total of 15,580 smolts (31.0%) were marked, 34,710 (69.0%) were unmarked.

release of relatively large (246/lb) fingerlings because of competition and/or predation; and (3) the resultant average annual smolt biomass production, compared to the 1973-1979 mean, is down by 608 kg (1,340 lb), or 28,000 smolts, for the past 2 years.

It is not understood whether the 1979 fingerling plant was solely responsible for the obvious setback in Bear Lake's smolt productivity, or if reduced nutrients in the water column have upset the natural salmonid food web thereby decreasing the lake's carrying capacity for juvenile coho salmon. If the latter phenomenon is the cause and effect, then the aforementioned artificial nutrient enrichment (fertilization) experiment may restore, or actually enhance, Bear Lake's coho salmon smolt production. Any changes in Bear Lake's smolt production will continue to be monitored at Bear Creek weir. Also, population studies of Bear Lake's juvenile coho salmon standing crop may be conducted annually to earlier define what effect, if any, that artificial fertilization is having on stocked fingerling growth to smoltification.

The negligible adult returns from the 1980 "0-Age" hatchery coho salmon smolt releases in Seward Lagoon and Grouse Lake attest that these fish were too small to adapt to ocean life or survive to adults. Zero returns were also reported for the 1980 0-Age smolt plants at Whittier and Homer (Hauser, pers. comm.). Seward Lagoon was test-netted on May 7, 1981 to detect presence of the 1980 0-Age smolt release that held over in the lagoon through the 1980-1981 winter. The test-netting CPUE of 1.33 coho salmon/net-hour indicated these fish were only one-third as abundant compared to the previous November CPUE of 4.00/net-hour. Apparently, since these fish were Age 1.0 in 1981, they had achieved sufficient growth to emigrate as normal smolts. About May 3-4, a large flock of sea gulls were reportedly fishing the Lagoon culvert outfall into Resurrection Bay. The 0-Age hatchery coho salmon smolts released in Seward Lagoon and lower Bear Creek in 1981 should realize much higher smolt-to-adult survival than the 1980 smolt plants due to their larger size (25/lb vs. 34-39/lb) at release.

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